The SECUREarth Initiative: A Town Hall Meeting

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November 9, 2004

Presented at:
GSA, Denver, CO

SECUREarth
urgent solutions to secure earth's future
Scientific Environmental/Energy Cross-Cutting Underground Research

Objective of Town Hall Meeting

- **Inform the Geoscience community about the SECUREarth Initiative and generate broad support.**
- **Solicit input on key roadblocks, research needs, and approaches.**

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Background and Motivation: Shrinking Resources for an Expanding Population

- Energy and environmental needs are accelerating at a pace much faster than current research can satisfy.
  - Increasing domestic and international energy demand
  - Environmental remediation and resource utilization
- Current Geoscience Research mode and scope will not meet societies needs in the next 20–25 years - How do we “harvest” current research and integrate results.
  - Alternative energy will not meet immediate needs
  - Mitigation of greenhouse gases
  - Water quality and supply
- Recent advances in supporting science can be used to accelerate fundamental knowledge to make significant advances.
  - NSF and DOE user facilities
  - Materials and microbiology advances
  - Computing
  - Characterization and Monitoring

SECUREarth

- New initiative for the geosciences addressing **S**cientific **E**nvironmental/Energy **C**ross-Cutting **U**nderground **R**esearch in the Earth or SECUREarth.
- SECUREarth's goal is to build a focused research activity to integrate and augment existing research programs and facilities at universities, labs and industry to overcome key environmental and energy roadblocks in a timely fashion.
- Will focus on the subsurface coupled processes (physical, chemical, microbial) affecting flow and transport of fluids.

Solving Cross-Cutting PROBLEMS in GeoScience

Environmental Clean-Up
- Natural Attenuation
- Bio/GeoEngineering
- Remediation

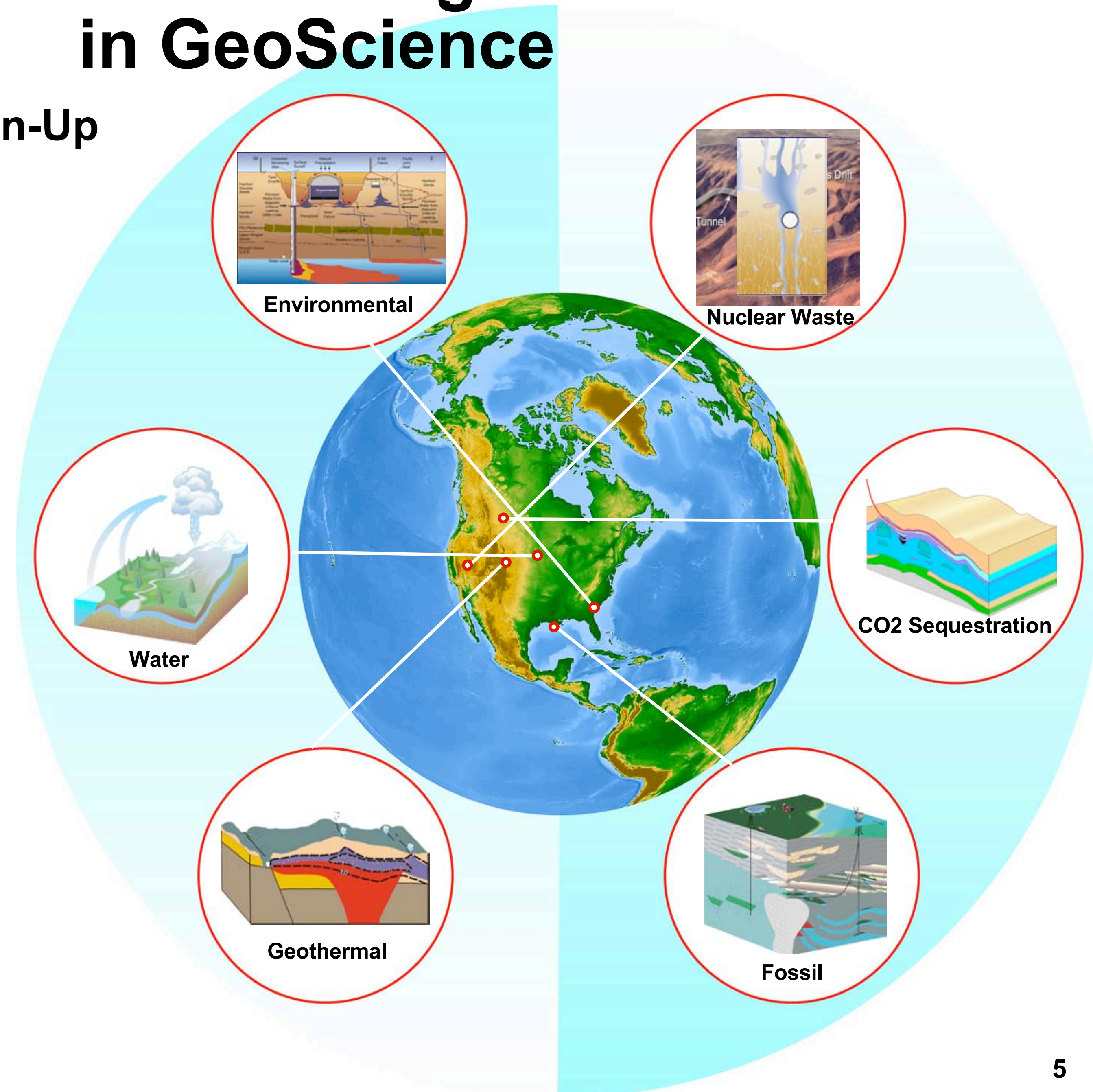
Nuclear Waste
- Flow Paths
- Transport
- Isolation

CO_2 Sequestration
- Storage
- Leakage/"Plugging"
- Sequestration

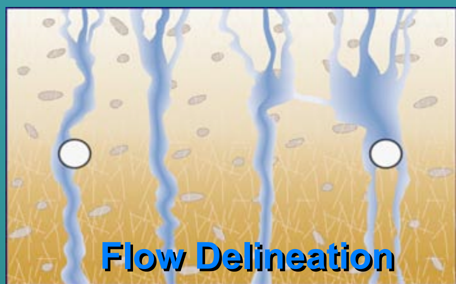
Fossil Energy
- Flow Paths
- Enhancement
- Recovery

Geothermal
- Fracturing
- Flow Manipulations
- Production

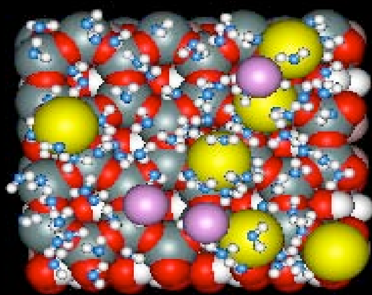
Water
- Recharge
- Quality
- Supply

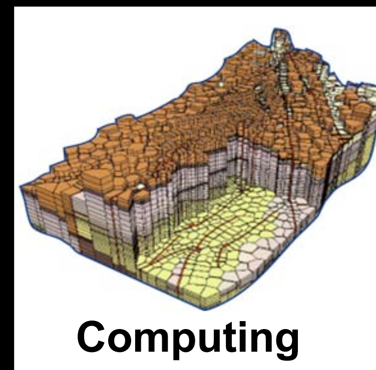


Cross-Cutting CHALLENGES



Flow Evolution





Research APPROACH

urgent solutions to secure earth's future
SECUREarth
Scientific Environmental/Energy Cross-Cutting Underground Research

History of SECUREarth

- **Developed by INEEL, LBNL, Oak Ridge, PNNL, and several universities (everyone is welcome).**
- **Multidisciplinary – Multi-institutional Advisory Panel formed in early 2004.**
- **NRC workshop in July 2004.**
- **Monthly teleconference on SECUREarth held first Thursday of every month at 10:30 a.m. (Pacific) *(http://www-esd.lbl.gov/SECUREarth)***

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Meeting of Opportunity on the SECUREarth Initiative

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George Hornberger and Pat Dehmer
Office of Science

NRC/DOE Introduction

SECUREarth Overview

Bo Bodvarsson Earth Sciences Division Director, LBNL Russ Hertzog Subsurface Science Initiative Director, INEEL	**Overview of the SECUREarth Initiative**
Fred Hoffman Vice President, International and Deepwater Exploration	**It Was Not a Lack of Stones That Ended the Stone Age**
Franklin W. Schwartz Ohio Eminent Scholar in Hydrogeology, The Ohio State University	**Organizing for Innovation In Geoscience Research**
Frederick Colwell Researcher, INEEL Ernest Majer, LBNL	**Elements of Successful Geoscience Research**

Feedback from Various Agencies

Pat Dehmer
Margaret Chu
Edith Allison
Mike Wright
Pat Leahy
Rien van Genuchten
James Woolford

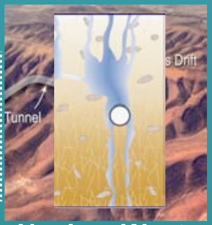
Margaret Leinen
Caroline Purdy
Jeffrey Marqusee
Noel Scrivner
Barry Katz, Fellow
Richard Coates
Mark Gilbertson

Key Results of NRC Workshop

- The two main themes that emerged were, "Diverse problems have similar solutions" and "isolate or produce".
- DOE OS was supportive and will sponsor a "decadal study" by NRC/NAS.
- The other speakers all addressed the questions and were supportive of the research goals. All identified crosscutting problems including:
  - Heterogeneity
  - Scaling
  - Imaging
  - Coupled processes
- Need to articulate new and compelling science.
- Need to focus science on the solution of a problem.

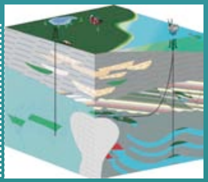
Lack of Predictive Capability: Examples

- **Nuclear waste disposal – meet 100,000 year standard?**

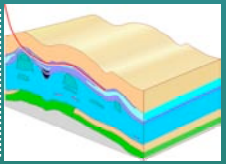


Nuclear Waste

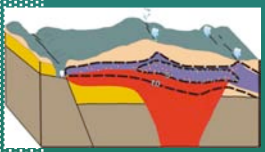
- **Oil and gas – why only 30 - 40 % maximum recovery?**


Fossil

- **CO_2 Sequestration - can it be safely stored long term?**


CO2 Sequestration

- **New and enhanced geothermal systems - ten fold?**


Geothermal

- **Environmental Remediation - Cost effective and safe?**

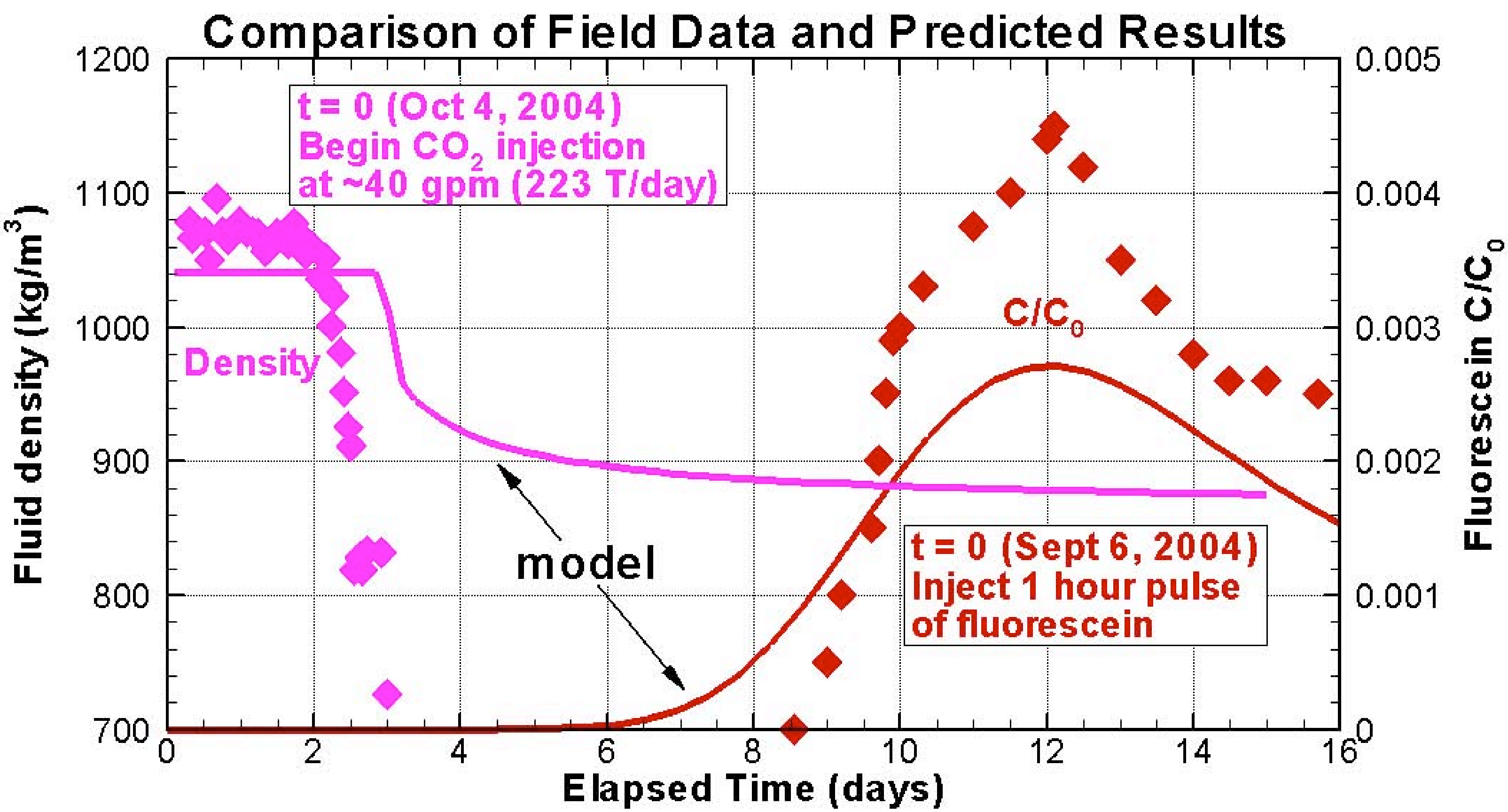

Environmental

- **Water supply and quality – Meet all future needs?**

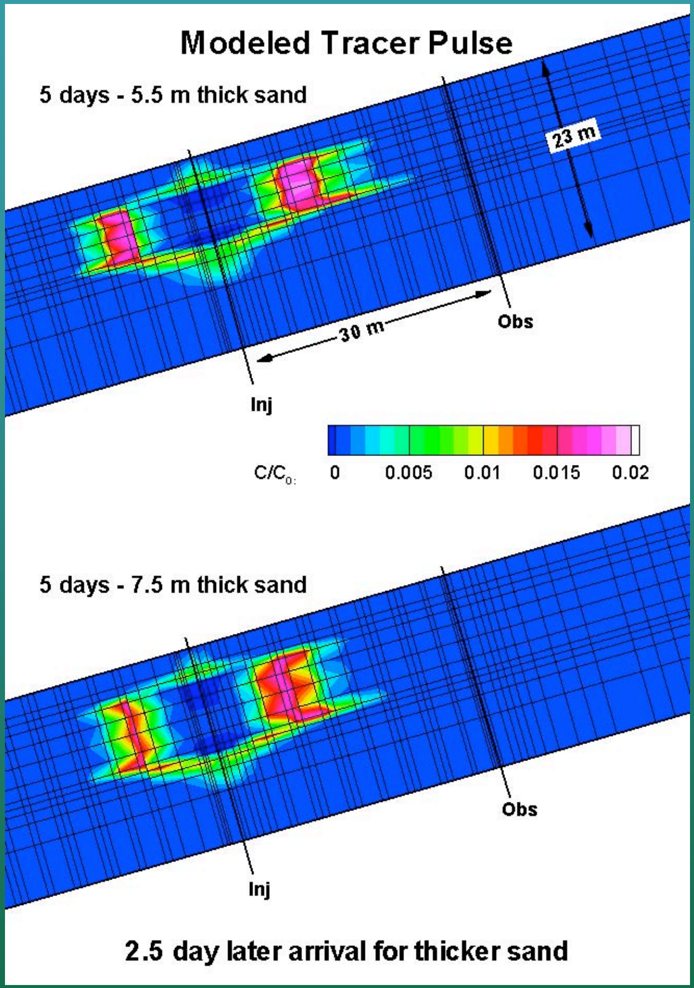

Water

TOUGH2 Simulations for the Frio Brine Pilot for CO_2 Sequestration

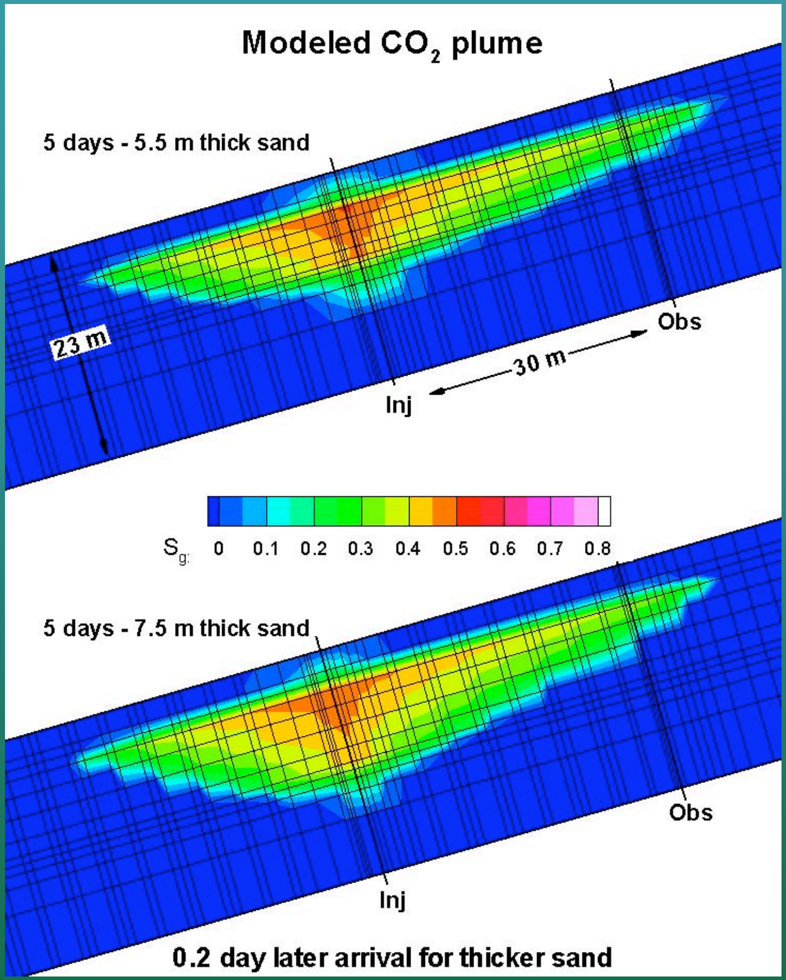
- Simulation of CO_2 injection behavior between two wells only 100 feet apart.
  - Geometry constrained by many well logs, surface seismic and other geophysics
  - 50 years of experience in the area
  - Tracer tests, interference tests
- High permeability, uniform unconsolidated sand formation.
- Numerous model runs over a year prior to, and after picking the monitor well site.
- Input from geochemists, geologists, and reservoir engineers.



Comparison of Field Data and Predicted Results
t = 0 (Oct 4, 2004)
Begin CO_2 injection
at ~40 gpm (223 T/day)
Density
model
C/C_0
t = 0 (Sept 6, 2004)
Inject 1 hour pulse
of fluorescein
Fluid density (kg/m^3)
Fluorescein C/C_0
Elapsed Time (days)
1200
1100
1000
900
800
700
0
2
4
6
8
10
12
14
16
0.005
0.004
0.003
0.002
0.001
0



Modeled Tracer Pulse
5 days - 5.5 m thick sand
23 m
30 m
Obs
Inj
C/C0:
0
0.005
0.01
0.015
0.02
5 days - 7.5 m thick sand
Obs
Inj
2.5 day later arrival for thicker sand


Modeled CO_2 plume
5 days - 5.5 m thick sand
23 m
30 m
Obs
Inj
S_g: 0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8
5 days - 7.5 m thick sand
Obs
Inj
0.2 day later arrival for thicker sand

Conclusions of CO_2 Experiment

- Mismatch could not be explained by not having the proper geometry.
- Lack of knowledge in proper fluid-rock interactions was the main gap.
  - Specific CO_2/brine capillary pressure relations at the field scale
  - Knowledge of the effect of heterogeneity in a multiphase system (preferential flow paths)
  - Proper mass balance (only one monitor well and lack of volume information)
- Sacrifices in experimental design had to be made due to the lack of understanding (guesses) in the hierarchy of process to monitor.

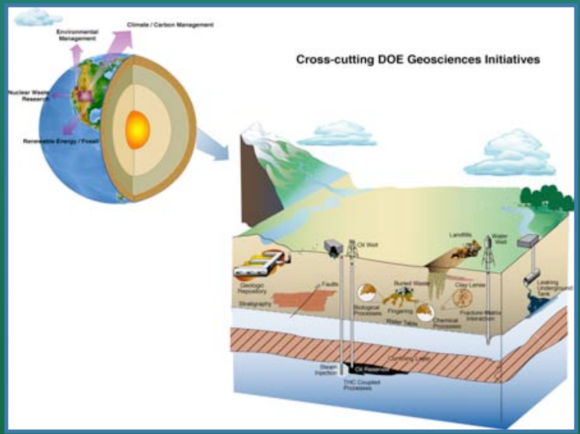
Scientific Thrusts

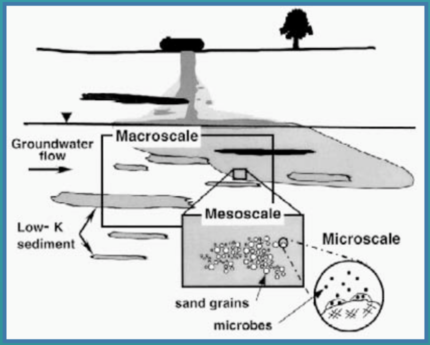
Develop fundamental understanding of crosscutting, complex, coupled processes that will permit imaging and manipulation of the subsurface for improved resource management.

- **Sustainable resource development (water, fossil fuels, CO_2 Sequestration, Geothermal)**
- **Environmental remediation**
- **Safe nuclear waste disposal**

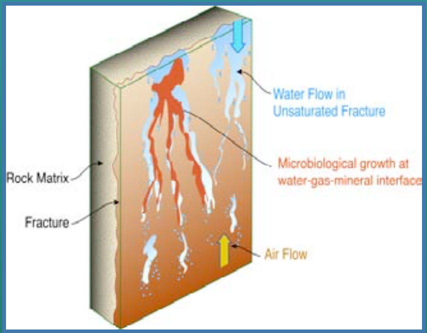
Build on Current Research, Not Replace

- **Multi-disciplinary**
- **Cross-cutting**
- **User Focused**
- **Science Driven**
- **Integrated Across Theory and Practice**

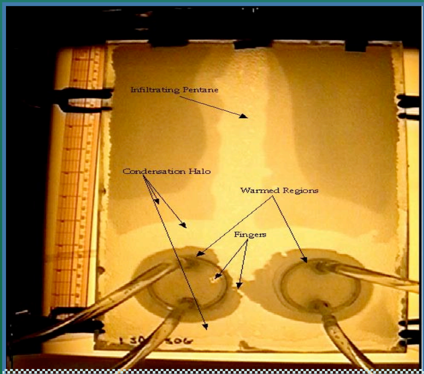




Scaling



Process Prediction



Ecosphere Manipulation

What Do We Need To Do Now?

- **Identify well defined, crosscutting research areas that have major impact.**
- **Package initiative goals so that they are readily understood and explained by policy makers.**
- **Define focused-project/program elements and their interrelationships.**
- **High-level champions.**

Need buy in and support by entire Geosciences community!

SECUREarth

Developing a research framework necessary to meet National energy supply and environmental quality requirements of the 21st Century.

SECUREarth

urgent solutions to secure earth's future

Scientific Environmental/Energy Cross-Cutting Underground Research

Existing, Complementary Components:

Field Study Sites:

DOE NABIR Field Research Centers
DOE Yucca Mountain Repository
NSF CUAHSI Observatories
DOE ARM Research Stations
USDA Remote Sensing Sites
NSF Deep Underground Sci. & Eng. Labs
CO2 Frio Formation Geo-Seq Site
USGS NAQUA and NRP Sites
DOD Serdp NETTS
RMOTC

Training & Outreach

DOE Stars! Program
NSF Education and Outreach
Universities
EPA Star Program
USGS Learning Web

Facilities

DOE Synchrotrons
EMSL
G:TL
BES Nanoscale Science facilities

Computation & Visualization

DOE Advanced Scientific Computing
Private Industry
Petroleum Industry
NASA

Synthesis

National Laboratories
Universities
JGI
NSF CUAHSI Synthesis
Water Agencies
Industry

Future of SECUREarth

- Host series of town hall meetings in 2004 and early 2005. (GSA, AGU, etc.)
- Small workshop involving Advisory Group scheduled at AGU (December 12, 2004).
- Focused workshop to set out specific scientific plan and implementation approach in spring of 2005.
- NAS/NRC study to commence on a fast track in 2004/2005.
- Final call for proposals to follow.
- Monthly teleconference on SECUREarth held first Thursday of every month at 10:30 a.m. (Pacific). (http://www-esd.lbl.gov/SECUREarth)

Discussion Questions

- What are the the key roadblocks in successfully applying geoscience research to solve energy and environmental problems?
- How do you see your research fitting in?
- What new approaches are needed in carrying out the science?

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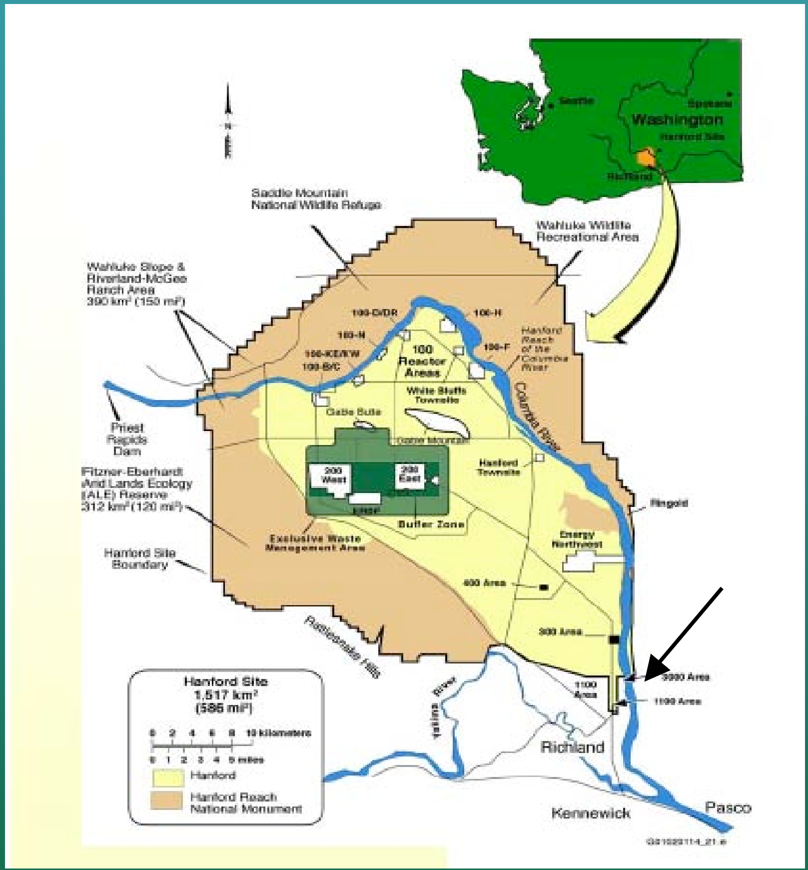
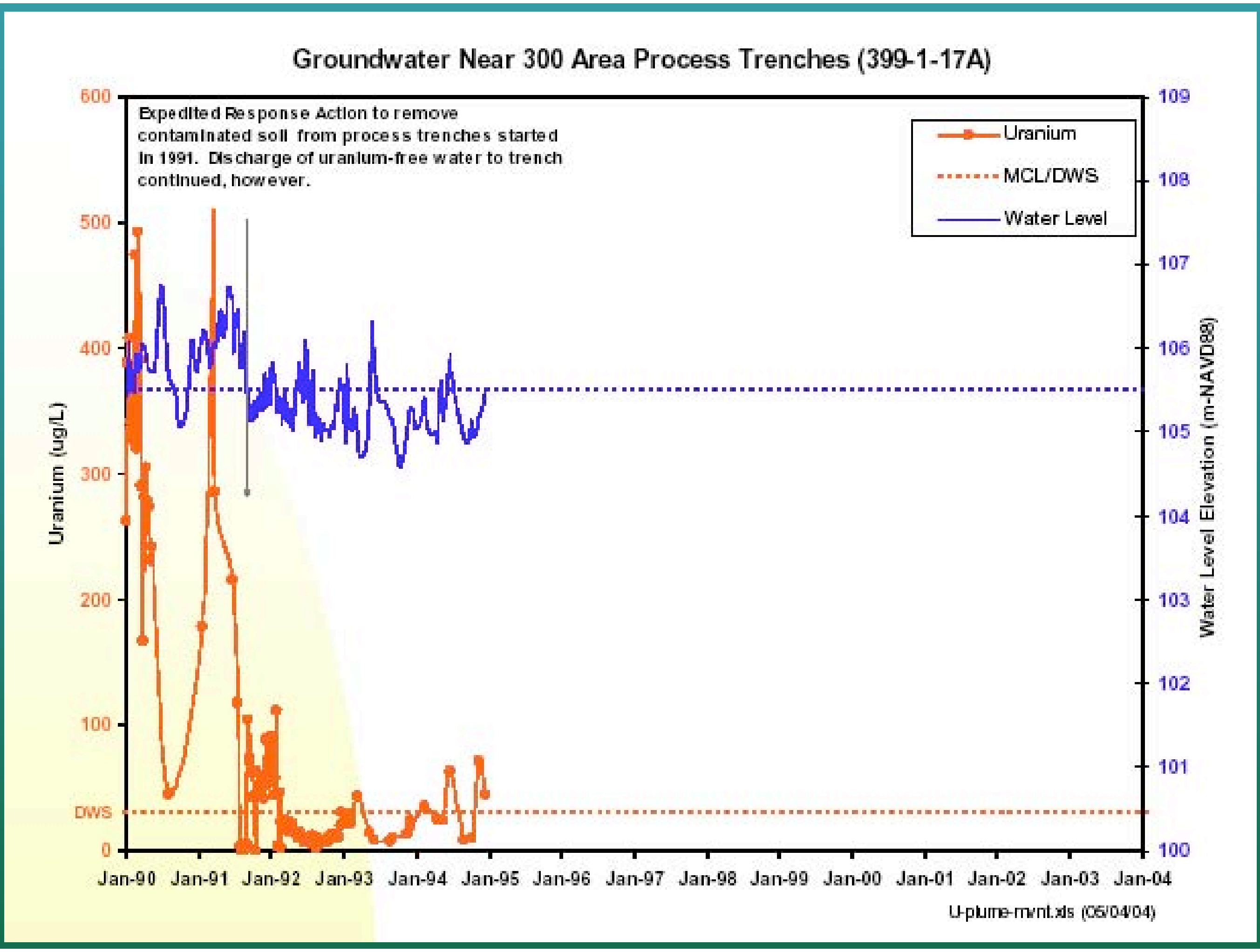
BACKUP SLIDES

Hanford Uranium Plume

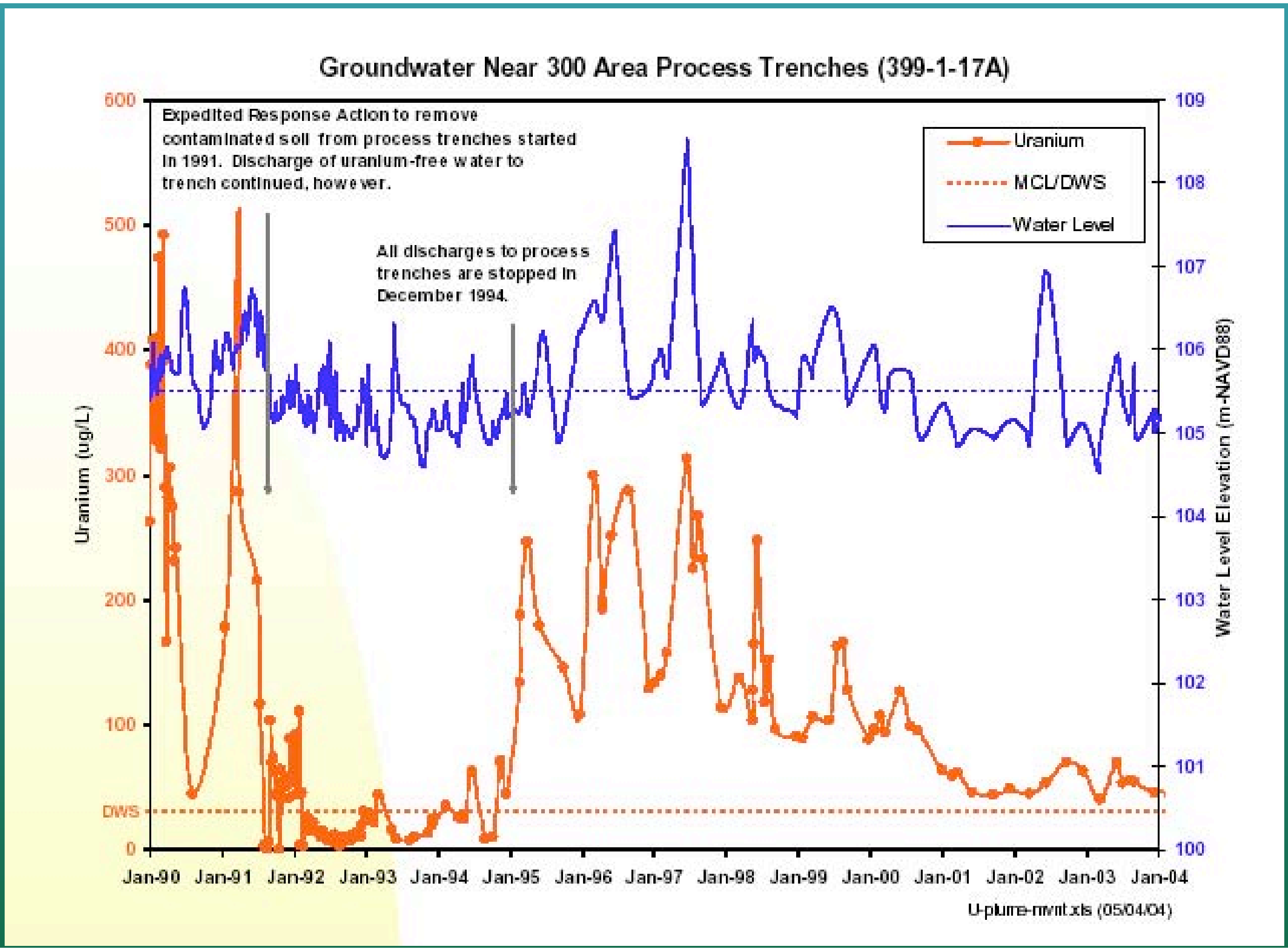
- Large volume (over 15 M Kg) of radioactive mixed waste placed in ponds: 1943 to 1975
- Vadose zone environment with gravels, sands, silts and clays, hydrologic gradient (0.5 to 10 m/day towards one of worlds largest river reaches less than 1 km away (up to 250,000 cfs).
- Remediation started in 1990(pump and treat) based on numerous well data and modeling
- Remediation stopped in 1995 based on “dramatic reduction in U concentrations near trenches



Remediation Results to 1995



Rebound After Remediation Stopped



Critical Unknown and Lack of Data

- Amount of uranium remaining in the vadose zone.
- Mobility of residual vadose zone uranium under likely future conditions.
- Characteristics of uranium in the vadose zone.
- Characteristics of uranium in the aquifer.
- Discharge of uranium into the river system.
- Potential consequences of uranium in the river ecosystem.
- Erroneous sorption parameter estimates
- Non-equilibrium geochemical processes (e.g., slow desorption)
- Desorption/dissolution from capillary fringe sediments
- Effects of contact time and water composition.

Implementation of SECURE Earth

Implement research results

- **Appropriate scientific oversight**
- **Adequate resources**
- **Involve user community**

Process adopted will identify critical roadblocks a each level (system-level, enabling technology level and fundamental science level) as well as research pathways.

- Define work from beginning to end: needs, research, technology development, and user implementation
- Specify how work will be done, not just what will be done
- Specify a productive mechanism that will not hinder creativity
- Recognize that some work solutions are fundamentally impossible

Identify process that will pick the critical challenges – those that will lead to the most impact when solved.